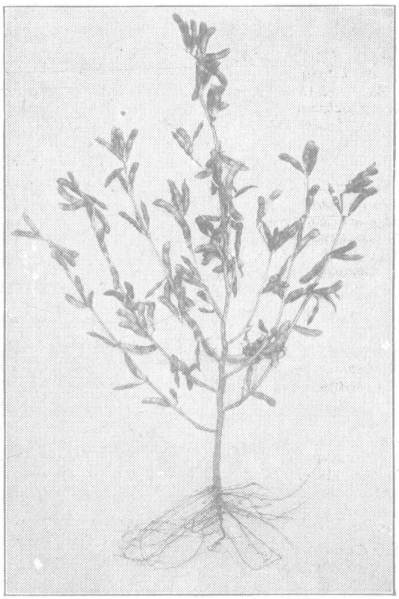
SOYBEANS: THEIR CULTURE AND USE

OHIO

Agricultural Experiment Station

WOOSTER, OHIO, U. S. A., MARCH, 1917

BULLETIN 312



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A field of soybeans ready to be cut for seed. Note that about half of the leaves have fallen

BULLETIN

OF THE

Ohio Agricultural Experiment Station

NUMBER 312 MARCH, 1917

SOYBEANS: THEIR CULTURE AND USE

C. G. WILLIAMS AND J. B. PARK

SOYBEAN CULTURE

C. G. WILLIAMS

Production in Ohio.—Among the newer legumes in Ohio, soybeans stand well toward the front. Statistics gathered by our township assessors and tabulated by the Ohio State Board of Agriculture show the following acreages of the more prominent legumes:

	Acres
Red and alsike clover	880,676
Alfalfa	79,454
Sweet clover	2,457
Soybeans	4,921
Peas	2,364

The county reported as having the largest acreage is Gallia, with 349 acres, and Washington is second with 323 acres. The county reported as having the largest production of soybean seed is Williams, with 1,900 bushels, and Tuscarawas is second with 459 bushels. The largest production of hay is reported from Fayette County, with 438 tons, and Washington is second with 426 tons.

This is the first year that soybean statistics have been gathered; accordingly, no comparisons can be made with the past. The acreage is undoubtedly increasing rapidly.

Place.—The place of soybeans in Ohio agriculture is not an unimportant one. They are being substituted for oats in such standard 4-year rotations as corn, oats, wheat and clover, and potatoes, oats, wheat and clover; likewise, in some 3-year rotations. However, their largest use for some time will likely be as a substitute crop for clover and grass where there have been failures of new seedings, or where for any reason there is a hurry call for an annual crop which will furnish a good yield of hay of high quality.

They are a peculiarly valuable substitute for clover for two reasons: First, they are not only equal, but actually superior to clover in feeding value; and, second, it is a much better practice from the standpoint of fertility maintenance to substitute a legume where a legume has failed than to substitute a grass, like one of the millets or sorghums, thus giving the entire rotation period over to the grass family, with its exhausting drain on the soil for nitrogenous plant food.

CLIMATE AND SOIL REQUIREMENTS

Climate.—Soybeans are adapted to a wide range of climate, doing well from the states immediately north of the Gulf states to the northernmost limit of corn growing. There is no part of Ohio which cannot grow soybeans successfully if suitable varieties are secured.

Soil.—Soybeans may be grown on almost any soil. Good crops of seed can be grown on rather thin soil if there is proper inoculation. On muck soils they tend to produce foliage at the expense of seed. They succeed on sands, silts and clays, but are perhaps at their best on loams. Well-drained soil is an advantage, though they will endure both excessive moisture and drouth. They will grow on acid soils better than red clover and alfalfa, but yet are helped by applications of ground limestone.

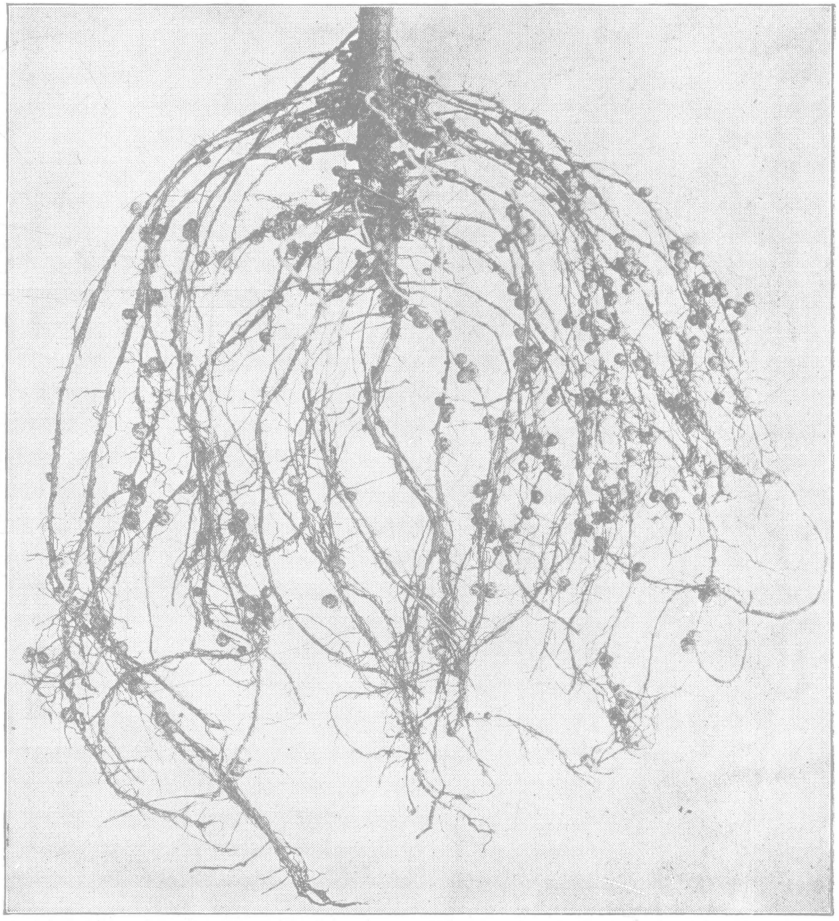
Fertilizers.—When soybeans follow corn, as is frequently the case, they seldom require direct applications of fertilizers. Land in condition to produce good corn will usually give good yields of soybeans. It is not necessary to apply nitrogenous fertilizers, but phosphorus and potassium are required in abundance. Unless the soil has been well phosphated for corn, it will be well to apply about 200 pounds of acid phosphate per acre at seeding time. With suitable provision for making the stores of potassium in the soil available during the rotation it may not be necessary to apply any carrier of this element.

Inoculation.—Legumes when introduced as new crops call for inoculation if best results are to be secured at once. The soybean is no exception to the rule. Inoculation may be accomplished in the most convenient way; by the use of soil from old soybean fields, or by means of bacterial cultures. The latter may be had from commercial firms or from the Federal Department of Agriculture at Washington, D. C. This Station does not distribute inoculating material.

A little infected soil (50 to 100 pounds per acre) if drilled in the row with the beans will give the best of inoculation.

The nodule-forming bacteria are usually found the second year that soybeans are grown on the same land, without artificial inoculation, if the soil conditions are favorable; that is, plenty of carbonate of lime, phosphorus and organic matter. Once in a soil the bacteria will live from one soybean crop to another, or at least over an interval of 4 years.

Soybeans will do well on rich land without inoculation, but it will be at the expense of the soil for nitrogen. Moreover, experiments conducted by the Michigan Experiment Station have shown that the presence of nodules on the roots affects the composition of the plant as to nitrogen content.



The root system of a soybean plant showing numerous nodules in which nitrogen-fixing bacteria live

SEEDING AND CULTIVATION

Seed bed.—Little need be said regarding the preparation of the seed bed for soybeans, as it is much the same as for corn. It should be firm below, with the surface 2-inches fine and mellow.

Time of seeding.—Soybeans are easily injured in the spring by frost. They come through the ground slowly and grow slowly in cool weather. Nothing is gained and frequently much is lost by planting too early. They will hardly stand as early planting as corn. Usually it is well to plant them 2 to 3 weeks later than corn, and they may be planted successfully some seasons 4 to 5 weeks later. It is important that they start promptly and grow rapidly. If they are checked by low temperature, foxtail and other weeds are likely to get the start of them. The planting dates for Ohio range from May 20 to June 20.

Manner of seeding.—Soybeans are usually planted in rows far enough apart to cultivate between them, or drilled solid—that is, every hoe of the grain drill is used. It is a waste of seed to broadcast and cover it with a harrow. Larger yields can be secured by having the rows 28 to 32 inches apart, but this is a little too close for the use of some two-horse cultivators. Thirty-six inches should be the maximum distance, however. Plants should be 2 to 4 inches apart in the row. Solid drilling calls for more seed, but is perhaps advisable for the production of hay. The yields will be somewhat larger and the hay of finer stems, if not as free from weeds.

Soybeans can be drilled satisfactorily with an ordinary grain drill. The larger, or oats feed should be used to avoid cracking the beans. By covering part of the feed cups the distance between the rows can be adjusted to meet the requirements. Corn planters are usually furnished with special plates for drilling beans.

Depth of seeding.—A caution should be sounded regarding planting soybeans too deep. At the best it is often a difficult matter for them to get above ground. With deep planting the difficulty is increased. There is seldom any occasion to plant deeper than 1 inch. If the ground is dry at planting and stays dry, 2 or 3 inches deep will do no harm, but in case of a beating rain and the formation of a crust on the surface the beans will not be able to come through. Such a crust should be broken with a smoothing harrow if it is safe to do so.

The sooner soybeans can be got out of the ground after planting the better will be the stand and the crop. Under ordinary spring conditions comparatively shallow planting favors this result.

Rate of seeding.—Tests have been conducted at different rates ranging from 1 to 4 pecks per acre in rows 28 inches apart, the Medium Green variety of soybeans being used; also at 8 pecks per acre in solid drilling with rows 8 inches apart. The results are recorded in Table I.

These results are a little inconsistent. The yields from 1 and 2 pecks per acre have averaged almost identical, which would of course be in favor of the 1-peck rate in net yield. Yet 3 pecks per acre has given a substantial increase and has been uniformly superior to the lower rates of seeding except in the very unusual season of 1916. As a 6-year average the net yield from 3 pecks has exceeded the yield from 1 peck by 1.73 bushels per acre, and the net yield from 4 pecks by 0.69 bushel. For seed production, then, 3 pecks of medium-sized soybeans would seem to be the most profitable rate of seeding.

The solid drilling with 8 pecks of seed per acre has given smaller yields of seed than any of the lower rates of seeding where the crop has been intertilled, though the yield of total forage has been higher. The 3-peck rate stands second in yield of forage. For hay, likely 8 pecks drilled solid will be profitable if seed is not worth more than $2.40 per bushel, which would make the increased yield of hay cost $10 per ton. The hay would have finer stems with the heavier seeding, which is some advantage, though attention should be called to the fact that foxtail and other weeds are likely to make up quite a proportion of the hay in solid drilling in seasons when excessive rainfall promotes weed growth. There would be fewer weeds if the crop were intertilled.

For silage uses the fineness of stems is not important, for the large, more or less woody stems are softened in the silo and become quite palatable. Since grain is important in the silage the 3-peck rate of seeding would seem to be best.

The different varieties of soybeans vary widely in the size of seed as will be noted by consulting Table II. One peck per acre of some varieties will provide more plants than 2 pecks of other varieties.

Cultivation.—When planted in rows far enough apart to make interculture possible, soybeans should receive from two to four cultivations, depending upon the season. With the rows 28 to 32 inches apart the ordinary two-horse corn cultivators can hardly be used and resort must be had to the one-horse implements. Those having 12 to 15 small teeth are to be preferred. With any considerable acreage it will be best to make the rows 34 to 36 inches apart, thus permitting more economical cultivation.

TABLE I.—RATE OF SEEDING

Rate per acre	Yield per acre														
	Total yield (pounds)							Threshed grain (bushels)							
	1909	1910	1911	1912	1913	1916	6-year average	1909	1910	1911	1912	1913	1916	6-year average	Net return
1 peck.	2,480	2,685	4,510	2,480	3,600	3,700	3,242	10 66	18 91	35.58	15.71	22 41	18.17	20.26	20 01
2 pecks.	3,640	2,775	4,216	2,440	2,800	3,630	3,250	16.58	20.08	33.78	16.12	18.00	17.33	20.31	19.81
3 pecks.	3,760	3,010	5,040	2,360	3,920	3,150	3,540	17.33	21.00	38.40	16.41	25.33	16.50	22.49	21.74
4 pecks.	3,640	3,345	4,608	2,720	3,560	2,580	3,409	16.08	23.16	36.35	20.58	23 58	12.58	22.05	21.05
8 pecks.	3,080	4,300	5 393	3,940	3 760	4,380	4,142	12.66	15.42	33.86	20.83	22.75	12 54	19.68	17.68

It is especially important that the cultivation be shallow and level. Many productive varieties are short in growth and it is necessary to cut them close to the ground. Rough, ridged cultivation makes this impracticable.

It is often a difficult matter to grow a clean crop of soybean hay when intercultivation cannot be practiced on account of the closeness of the rows, as in the case of solid drilling (rows 8 inches apart) or where every other drill cup is covered, making the rows 16 inches apart. The best possible cultivation in these cases may be given by running a weeder over the field across the rows once before the beans come through the ground and again when they are about 3 inches high. This work should be done in the heat of the day when the beans are tough, or else they will break off badly. One should avoid doing this work just as the beans are coming through the ground. Under ordinary conditions such use of the weeder will result in a clean field of soybean hay.

HARVESTING

For hay.—Soybeans should be cut for hay when the pods are well formed. If left much later the quality of the hay will depreciate as a result of the loss of leaves and the hardening of the stems. The protein content will also decline.

The usual implements of the hay-harvest field may be used, particularly the mower and the rake. The soybeans should be mowed after the dew is off, raked when well wilted and allowed to cure in windrow and hay cock until safe to store. Soybeans require about the same curing as clover. Rains go through the cocks readily; and, if overturned and opened up slightly an hour or two before hauling, the hay should be in good condition.

For silage.—The seed should be well developed for silage, but the cutting should precede any considerable loss of leaves. The best implement to use for this purpose is unquestionably the ordinary grain binder. This puts the beans in excellent shape for rapid handling on the way to, and through the silage cutter.

Soybeans do not make a desirable silage by themselves, being too rich in protein and fat; but when mixed with twice as much corn they make a feed that is both palatable and productive.

For seed.—When grown for seed, soybeans should be allowed to stand until nearly mature. In the case of some varieties this may mean until most, if not all of the leaves have fallen. Varieties which shatter easily, like the Medium Green, should be cut when about half the leaves have fallen. Soybeans should obviously be cut a little earlier in a hot, dry fall than in a cool, moist fall.

The best available implements for cutting soybeans for seed are the mowing machine with side-delivery attachment, the self-rake reaper and the grain binder. These implements should be used when the dew is on, or on a damp, cloudy day, to avoid shattering, and all handling of the beans as in bunching or shocking should be done under like conditions for the same reason. The careless workman by cutting over-ripe beans in the middle of the day with an ordinary mower, driving directly over the mowed beans, and raking and handling them without regard to conditions will finally arrive at the huller or thresher with straw entirely devoid of beans.

Soybeans will go through quite a rainy season after cutting without serious loss if the cocks are turned bottom up from time to time, thus avoiding the molding of the beans from contact with the damp ground.

Threshing.—It will usually be found more convenient to thresh soybeans from the field than to stack or store in barns. It is a difficult matter to avoid cracking many beans in using an ordinary grain separator. It helps somewhat to reduce the speed of the cylinder by means of special pulleys which allow the rest of the machine to run normally, and to use blank concaves, but it is hardly possible to avoid all cracking. A grower in the business permanently in a large way will doubtless find it advisable to secure a special pea and bean separator. Areas of 1 or 2 acres can readily be threshed with a flail. There is no other crop that shatters as easily.

Care must be taken not to store soybeans in large quantities after threshing until they are thoroughly dry. Otherwise they will heat and the germination will be seriously impaired, if not destroyed.

VARIETIES

For seed production.—Within the last 6 years this Station has tested, on the average, about 70 varieties and pure-line strains each year. Of these 25 are described in Table II. These descriptions will aid in the identification of varieties and give some information as to the comparative length of season. The dates of blooming and ripening as well as the number of days from planting to maturity are for 1915. These dates vary widely with the season and with the time of planting. One variety (the Sable) did not ripen fully before the killing frost of October 10, 1915. The first column of this table gives data regarding the comparative size of beans which should be considered in the seeding rate of soybeans. Obviously a variety having 40 to 50 beans per 10 grams will need heavier seeding than one having 150.

TABLE II.—DESCRIPTION OF VARIETIES

Variety	Number of beans per 10 grams	Color of beans	Date of bloom	Color of bloom	Date of ripening	Number of days from planting to maturity
Amherst	53	Yellow	7-25	Purple	10-1	113
Auburn	75	Black	7-24	White	9-21	103
Cloud	126	"	8-10	White	10-9	121
Ebony	88	"	7-23	Purple	9-25	107
Elton (Chestnut)*	55	Yellow	7-23	"	9-24	106
Habaro	63	"	7-23	"	9-28	110
Hollybrook	91	"	7-30	"	10-1	113
Ito San	69	"	7-22	"	9-17	99
Ito San 17268	82	"	7-20	"	9-17	99
Manchuria	68	"	7-24	"	9-16	98
Medium Green	69	Green	7-24	"	9-25	107
Mongol	89	Yellow	7-26	"	10-1	113
Mikado	86	"	7-30	"	10-5	117
Ohio 7491	49	"	7-24	"	10-2	114
Ohio 7496	43	"	7-24	"	9-25	107
Ohio 9001	55	"	7-20	White	9-17	99
Ohio 9016	53	"	7-22	Purple	9-25	107
Ohio 9035	60	Brown	7-26	"	10-4	116
Ohio 9100	69	Yellow	7-21	"	9-17	99
Ohio 9110	70	Green	7-24	"	9-25	107
Sable	154	Black	8 16	White	Not ripe	.....
Shingto	56	Olive	7 26	White and Purple	10-2	114
Taha	53	Black and Yellow	8-8	White	10-7	119
Wing's No. 1	137	Black	7-31	"	10-1	113
Yosho	66	Olive	7-25	"	10-1	113

*The Elton was first sent out by the U. S. Department of Agriculture under the name of Chestnut.

In Table III are given the yields of the 25 varieties described above for five different seasons, the 5-year average yields of grain and straw, and the average number of pounds of straw per bushel (60 pounds) of grain.

TABLE III.—YIELDS OF GRAIN AND STRAW OF DIFFERENT VARIETIES

Variety	Yield per acre							Pounds of straw per bushel of grain
	Grain (bushels)						Straw (pounds) 5-year average	
	1911	1912	1913	1915	1916	5-year average		
Amherst	31.82	28.49	16.73	20.99	17.55	23.12	2,390	103
Auburn	24.98	29.08	17.08	22.91	17.05	22.22	2,110	95
Cloud	26.40	23.14	19.40	10.24	12.52	18.34	2,510	137
Ebony	27.32	28.03	18.07	27.33	18.13	23.78	2,166	91
Elton (Chestnut)	28.17	34.69	20 51	30.19	18.97	26.51	1,906	72
Habaro	24.70	30.02	18.91	25.85	19.03	23.70	2,134	90
Hollybrook	.....	30.35	16.07	24.35	16.49	21.81	2,287	105
Ito San	25.54	20.41	18.42	23.46	18.00	21.17	1,956	92
Ito San 17268	27.81	31.31	20.09	31.02	18 94	25.83	2,170	84
Manchuria	27.98	30.53	18.74	26.27	17.55	24.21	1,896	79
Medium Green	30.90	28 69	17.91	29.74	12.11	23.87	2,185	91
Mongol	29.81	36.63	16 31	20.94	16.63	24.06	2,278	95
Mikado	27.57	31.19	14.36	13.64	12.50	19.85	2,114	106
Ohio 7491	31.60	32 59	20.53	20.41	17.50	24.53	2,638	108
Ohio 7496	34.62	31.77	21.35	31.71	20.56	28.00	2,372	85
Ohio 9001	30.90	25.84	19.68	27.38	16.22	24.00	1,964	81
Ohio 9016	33.15	33 08	25.69	32.85	21.33	29.22	2,236	77
Ohio 9035	37.37	31.55	16.62	16.77	15.16	23.49	2,636	112
Ohio 9100	23.18	21.35	20.83	22.34	18.72	21.28	1,982	93
Ohio 9110	34.15	29.35	17.62	32.93	6.83	24.18	2,312	96
Sable	19.06	23.58	10.24	7.63	9.55	14 01	2,292	164
Shingto	31.74	32.36	19.85	19.74	19.66	24.67	2,396	97
Taha	29.45	31.52	17.58	8.00	12.84	19.88	2,786	140
Wing's No 1	25.98	26.61	13.16	22.99	17.44	21.24	1,696	80
Yosho	25.58	29.47	17.24	13.69	10.40	19.28	2,262	117

The highest five yielders, in order of their rank, are Ohio 9016, Ohio 7496, Elton[1], Ito San 17268 and Shingto. The lowest five yielders are Sable, Cloud, Yosho, Mikado and Taha.

It is of interest to note that the highest yielders of grain have a comparatively low proportion of straw to grain, ranging from 72 to 97 pounds of straw per bushel of grain and averaging 81 pounds. In the lowest five yielders the range is from 106 to 164 and averages 133 pounds. While this is true the total yield of straw in the two classes varies but 177 pounds per acre on the average.

YIELDS AT THE COUNTY EXPERIMENT FARMS

A few of these varieties have been tested at the county experiment farms. The results of these tests are recorded in Table IV.

As an average of the 4 years' tests in Miami County, the Ohio 7496 stands first in yield and Ohio 9035 second.

In the Clermont County tests of 2 years, the Mongol is first and the Elton second.

In the Hamilton County test of 4 years, Ohio 9035 stands first and Ebony second.

In the Washington County tests of 2 years, Ohio 9035 is first and Elton second.

In the Paulding County tests of 2 years, Elton is first and Ohio 9035 second.

In 1 year's work in Trumbull County, Ebony is first and Elton second.

TABLE IV.—VARIETY TESTS AT THE COUNTY EXPERIMENT FARMS

(Average yields in bushels per acre)

Variety	Wooster 5 years	Miami 4 years	Clermont 2 years	Hamilton 4 years	Washington 2 years	Paulding 2 years	Trumbull 1 year
Elton[1]	26.51	20.48	6.78	12.42	15.84	25.00	18.09
Ebony	23.78	19.61	4.89	17.19	12.25	18.14	23.45
Medium Green	23.87	19.44	6.39	11.58	10.39	13.69	13.56
Mongol	24.06	20.72	9.03	17.11	14.70	17.37	.....
Ohio 7496	28.00	21.81	.....	14.89	.....	19.95	16.38
Ohio 9016	29.22	18.76	.....	12.98	.....	17.45	11.31
Ohio 9035	23.49	20.94	5.81	17.32	16.73	22.42	.....
Ohio 9100	21.28	17.34	3.42	12.89	14.97	18.78	16.95
New Era cowpeas	7.33	6.11	.33	5.03	1.58	.....	.....

[1]Formerly called Chestnut.

In so far as the county tests are concerned, Ohio 9035 is first in two counties and second in two; Elton is first in one county and second in three; Ebony is first in one and second in one; Mongol is first in one, and Ohio 7496 is first in one county.

For hay.—For the last 5 years tests have been conducted with 10 varieties of soybeans at Wooster in the production of hay. As a rule the hay has been cut when the beans were well podded.

The yields of hay are given for each year and the average for the 5-year period in Table V. The Medium Green has led by a margin of 548 pounds per acre. The Ito San, Shingto, Auburn and Ohio 9035 are next in order, each having yielded more than 4,800 pounds of hay per acre as a 5-year average, with the variation between them being less than 40 pounds per acre.

The lowest yielder of the 10 is the Mammoth Yellow. The northern half of the State is evidently too far north for this variety, even when grown for hay.

The Medium Green is a heavy yielder of hay. It is better adapted to the production of hay than grain on account of its objectionable habit of shattering.

TABLE V.—SOYBEAN HAY TEST

Variety	Total yield per acre (pounds)						Rank
	1912	1913	1914	1915	1916	Average	
Ito San	5,015	6,140	4,340	6,075	2,700	4,854	2
Medium Green	5,856	6,260	3,830	6,666	4,400	5,402	1
Ebony	5,334	5,280	4,070	5,400	3,700	4,757	7
Shingto	6,099	5,460	4,440	4,556	3,700	4,851	3
Ohio 9035	5,129	4,300	3,470	5,991	5,200	4,818	5
Cloud	5,703	4,800	3,270	4,894	5,200	4,773	6
Taha	4,670	5,180	3,100	5,231	4,900	4,616	8
Sable	5,027	4,800	3,080	4,894	.....	4,450	9
Mammoth Yellow	4,606	.....	2,840	3,712	4,100	3,814	10
Auburn	5,972	5,440	3,820	4,978	3,900	4,822	4

THE EFFECT OF SOYBEANS IN CROP ROTATIONS

Presumably the substitution of a legume for a cereal in a crop rotation will work to the advantage of the other crops of the rotation. With a view of investigating this and many other problems relating to crop rotation, work was recently started on a new farm which has come under the control of the Station in which some 50 different rotations are being tested.

Twenty-four plots of wheat were harvested in these different rotations in 1916. Ten of them followed a crop of corn of the year previous; six followed soybeans; five followed potatoes, and three followed oats. It is a significant fact that the average yield of wheat following soybeans was 10.3 bushels greater than that following corn; 1.27 bushels greater than that following oats, and a small fraction (0.34 bushel) greater than that following potatoes. The latter crop has long been known to be one of the most favorable for wheat. The early and thorough preparation of seed bed made possible by the early maturing and harvesting of oats has been uniformly more favorable for wheat than the preparation when this crop follows corn; but it seems that soybeans, though retaining use of the ground until late in the season, furnish a seed bed equal, if not superior, to those prepared after crops ordinarily considered the best. The yields of the several plots reported in Table VI are strikingly uniform.

TABLE VI.—WHEAT YIELDS FOLLOWING CROPS OF

Corn	Soybeans	Potatoes	Oats
Bushels	Bushels	Bushels	Bushels
28.83			
30.87			
29.37	37.58	39.42	
29.87	39.29	39.75	36.79
28.29	39.58	34.12	37.50
21.58	39.79	38.12	37.43
28.00	35.96	39.42	
21.21	38.87		
26.67			
27.46			
Ave. 28.21	38.51	38.17	37.24

In the rotation tests in question the average annual treatment of the soil as regards limestone, manure and phosphorus is the same. The wheat was treated with acid phosphate in every instance.

More time will be required to tell the effect of the growing of soybeans upon the other crops of the rotation, but the effect upon the wheat crop is quite evident in the first rotation.

USES OF SOYBEANS

J. B. PARK

Before the growing of soybeans can become a general practice among cornbelt farmers an outlet for the crop must be provided. If soybeans were used only as a substitute for clover when that crop fails the entire bean crop could probably be used for hay. However, if soybeans are to replace oats in the rotation it is not likely that the whole crop will be needed for hay, but that it will be allowed to ripen and be harvested as a grain crop. At present growers have little trouble in disposing of their crop at $2 to $3 per bushel for seed purposes. As long as the beans can be sold for seed at these prices they are a profitable money crop. To many men, however, this method of selling a crop is objectionable. More or less advertising is required, which is both troublesome and expensive; the sales are irregular and somewhat uncertain, and the whole crop cannot be converted into money at will as can be done with other grain crops. Moreover, if the growing of soybeans were to become general the seed market would soon be overstocked and the price would fall, leaving the farmer with a crop on his hands for which there would be no market.

It seems necessary, therefore, that before the growing of soybeans can become general a stable market must be developed, and this would necessitate that extensive uses be made of the beans for other than seed purposes. Fortunately, soybeans are suited to a great variety of uses; for animal food, human food and industrial uses. The reason for this is evident when it is known that soybeans contain more than 40 percent of protein and about 17 percent of fat.

USE FOR ANIMAL FOOD

Hay.—Soybean hay is about equal in feeding value to alfalfa hay, and slightly richer than clover. The leaves are the most valuable part of the hay; hence, it is important, as previously noted in this bulletin, to harvest and handle the crop in such a way that as many leaves as possible are retained.

Grain.—Soybeans are equal in feeding value to cottonseed meal and linseed oilmeal. At an average price of $33 per ton for these concentrates the value per acre of a 20-bushel crop of soybeans would be $19.80 for the grain only. This is but little more profitable than a good crop of oats, but with a higher price for concentrates the bean crop becomes more valuable. At $40 a ton 20 bushels of beans is worth $24.

Soybeans should be ground when fed to horses and cattle, but for sheep and hogs this is unnecessary. On account of the high concentration of protein they should be fed in mixture with a less concentrated feed, such as corn. The grinding of the beans is easier if the corn and beans are first mixed and then ground together.

Soiling crop.—Soybeans are an excellent soiling crop, and, being of relatively high protein content, they are well suited to feed along with corn, which is deficient in protein. Since soybeans are quite drouth-resisting, they will furnish green forage in the summer when pastures are likely to be short.

SPECIAL USES AND PRODUCTS

Soybean meal.—Soybean meal, from which the oil has been removed by pressure or extraction with solvents, has become a product of considerable importance in Europe and is beginning to attract attention in America. The oil mills of Europe import large quantities of soybeans, chiefly from Manchuria. The oil finds a ready market for a variety of uses, and the meal or cake left after removal of the oil is sold to dairymen. In 1912 Germany consumed 50,000 tons of soybean meal, as compared with 332,839 tons of cottonseed meal. In the same year England imported 188,693 tons of soybeans and produced 31,802 tons of oil and 151,000 tons of meal. Denmark is a heavy user of soybean cake and has recently established a number of oil mills which use beans imported from Manchuria.

The composition and digestibility of soybean meal in comparison with a number of other oil meals and grains are given in Table VII.[1]

The feeding value of soybean meal is recognized as equal to that of the other oilmeals. The table shows a high digestibility of both protein and oil.

Two methods are used for obtaining the oil; one by hydraulic pressure, the other by means of solvents. By the first method the beans are crushed into meal, treated with steam and then subjected to pressure. This process leaves 4 to 9 percent of oil in the cake. In the extraction method the beans are crushed and then treated directly with a solvent, such as benzine, which removes the oil. The solvent is separated from the oil by distillation and used again. The odor of the solvent can be entirely removed from the meal, leaving a light-colored product with only about 1 percent of oil and 43 to 45 percent of protein.

[1]U. S. Dept. Com., Bur. For. and Dom. Com., Special Agents Series No. 84 (1914), Pt. I, p. 35.

Soybean oil.—The oil, which is classed as a semidrying oil, is being used extensively by paint manufacturers. The United States Commerce Reports state that in 1915 there was imported into this country 21,335,213 pounds of soybean oil valued at $931,791. The oil is used in the manufacture of paints, varnishes, linoleums and soaps and is also being refined for use as a salad oil and as a lard substitute.

TABLE VII.—PERCENTAGE COMPOSITION AND DIGESTIBILITY OF SOYBEAN MEAL AND OTHER FOODSTUFFS FOR COMPARISON

Foodstuffs	Water	Crude protein	Crude fat	Nitrogen-free extract	Crude fiber	Total digestibility	Assimilability	Digestible albuminoids	Starch equivalent
OIL MEALS:									
Cottonseed—									
Decorticated—									
Analysis	8.0	46.2	8.9	22.9	7.0				
Digestible		39.7	8.4	15.3	2.0	76	97	38.0	71.0
Linseed—									
Pressed—									
Analysis	11.0	33 5	8.6	31.7	8.7				
Digestible		28.8	7.9	25.4	4.3	79	97	27.2	71.8
Extracted—									
Analysis	10.2	37.4	3.8	32.7	9.1				
Digestible		32.2	3.4	26.2	4.5	78	96	31.4	64.8
Peanut—									
Analysis	9.8	44.5	9.2	23.8	5.2				
Digestible		40 0	8.3	20.0	.8	83	98	38.7	75.7
Soya—									
Pressed—									
Analysis	11.2	43.5	5.0	27.2	7.0				
Digestible		39.2	4 4	25.6	5.5	90	96	38.4	74.7
Extracted—									
Analysis	11.5	45.2	2.0	27.5	7.3				
Digestible		41.6	1.4	27.5	7.2	97	96	40.7	73.0
CORN:									
Analysis	13.0	9.9	4.4	69.2	2.2				
Digestible		7.1	3.9	65.7	1.3	90	100	6.6	81.5
OATS:									
Analysis	13.3	10.3	4.8	58.2	10.3				
Digestible		8.0	4.0	44.8	2.6	70	95	7.2	59.7
WHEAT BRAN:									
Analysis	13.2	15.5	4.8	54.0	8.0				
Digestible		12.9	3.7	40.5	2.1	79	79	11.1	48.1

The first extensive use of American-grown soybeans for oil production was in North Carolina in 1915 and 1916, when between 80,000 and 100,000 bushels were crushed by the cotton oil mills. The manufacturers found ready sale for the oil, and fertilizer companies took the entire output of cake. The farmers received from $1.05 to $1.25 a bushel for the beans.

That considerable quantities of soybean cake and oil are being used in this country is shown by the imports given in Table VIII[1].

[1]U. S. Dept. Agr.; Bur. Plant Ind. Bul. 439 (1916), p. 9.

TABLE VIII.—QUANTITY AND VALUE OF IMPORTS OF SOYBEANS, SOYBEAN CAKE, AND SOYBEAN OIL INTO THE UNITED STATES, 1910 TO 1915, INCLUSIVE*

Year	Soybeans		Soybean cake		Soybean oil	
	Quantity	Value	Quantity	Value	Quantity	Value
	Pounds	*Dollars*	*Pounds*	*Dollars*	*Pounds*	*Dollars*
1910					Not Stated	1,019,842
1911			†2,115,422	59,626	41,105,920	2,555,707
1912			†2,416,052	64,350	28,019,560	1,576,968
1913			7,004,803	93,002	12,340,185	635,882
1914	1,929,435	49,507	3,163,260	38,255	16,360,452	830,790
1915	3,837,865	87,306	5,975,592	64,307	19,206,521	899,819

*Compiled from Dept. Com., Bur For and Dom Com., For Com and Nav U S 1910 1915

†Includes bean cake, or bean stick, miso, or similar products, with duty, 40 percent

Thus in looking toward the establishing of an American soybean industry we see that one important condition favorable to the enterprise already exists, namely, a market for the products.

USE FOR HUMAN FOOD

For many centuries soybeans have been used as human food by the people of China and Japan. The beans form the chief source of protein in their diet, supplementing rice, which is so extensively used and contains a great excess of carbohydrates. These people keep few livestock and eat but little meat. They believe it is the part of economy to eat vegetables rather than to feed them to animals and then eat the animals. They evolved centuries ago a system of agriculture by which crop yields can be maintained indefinitely at a high level, and also a dietary by which with little or no foreign aid they can nourish a population of many times the density of ours. In these days when the cost of living is on everyone's tongue and food riots are occurring among the poor of our cities, is it not wisdom to turn our eyes upon the people who met and solved similar problems while America was still a vast hunting ground for the Indian?

In Japan and China the whole beans are not used to a great extent, but several food products are manufactured from them. The principal products are soy sauce (shoyu), bean milk, bean curd (tofu), natto and miso; the latter being a ripened vegetable cheese.

Soy sauce.—Soy sauce (shoyu) is a dark-brown, very salty liquid with an odor and taste suggesting beef extract. It is used for a flavoring, and is as indispensable to an Oriental kitchen as salt is to ours. It is estimated that about 2.5 ounces of soy sauce is consumed daily by each Japanese. Equal parts of soybeans and

wheat are used in the manufacture, and the process is from 1 to 2 years long. There are no factories in this country. The characteristic flavor of chop suey is due to soy sauce, which is an essential part of that dish. Soy sauce can be obtained at the Chinese markets in most of our cities, and it might well find a place in our kitchens for use in gravies, soups, and with vegetable dishes which have not much flavor of their own. The food value of this sauce, however, is only slight.

Soybean milk.—When finely ground soybeans are mixed with about 10 parts of water and heated near the boiling point for 15 to 30 minutes, an emulsion is obtained which is remarkably similar in appearance and properties to cow's milk. Upon standing for a while the particles of meal will settle out and the liquid can be poured off. The liquid remaining in the residue can be separated by pouring the mass into a cloth bag and shaking until the liquid has run out. If allowed to stand quietly the filtration is extremely slow.

The liquid thus obtained has a yellowish white color, and it is a permanent solution or suspension of fat, protein and other materials, for it does not settle out on standing if fermentation is prevented. The composition of this liquid is about as follows: protein, 3.7 percent; fat, 2.0 percent; carbohydrates, 1.8 percent and salts, 0.5 percent.

If a small amount either of acid or of magnesium or calcium salts is added to the liquid, or if it is allowed to stand until sour, a curd is formed which settles out, leaving a clear, yellowish, watery liquid. The grayish white curd can be drained, pressed and eaten like cottage cheese. When salted and fried it is palatable, and can be used as a salad. This bean curd is the tofu which is so extensively eaten in the Orient. It is made fresh every day, and is as staple an article of diet of Oriental peoples as bread is of ours. As used by the Japanese these cakes contain 83 to 88 percent of water, 7 to 11 percent of protein and 4 to 5 percent of fat.[1]

The vegetable milk produced as described above has a rather strong odor and taste and is not palatable as a beverage or in cooking dishes in which milk is the chief constituent. It has been used, however, with success in a variety of preparations, such as breads and cakes, in creaming vegetables, in milk chocolate, etc. Approximately 10 pounds of this vegetable milk can be produced from 1 pound of bean meal, or 600 pounds from a bushel of beans, which makes it an exceedingly cheap product. This preparation may prove to be useful in feeding young stock, calves, pigs, or poultry,

[1]Soybean curd, Philippine Jour Sci. 7A (1912), pp 47 51

but not until careful experiments have shown what additional substances are needed to make it a whole food. The residue left after most of the soluble materials have been removed is still rich in protein and is valuable for animal feeding or for fertilizer.

Experiments are in progress at The Ohio State University by which it is hoped to find a simple method of preparing the vegetable milk free from objectionable odor and taste. Already a method has been found which gives a fairly good product and this has been used in a few preliminary experiments by Miss Anna R. Van Meter of the University Department of Home Economics. The soybean milk was substituted for cow's milk in the preparation of custard, white sauce and corn starch pudding, and proved to be fairly satisfactory. It served well also as a milk substitute when eaten with bread as ordinary "bread and milk." Used with either coffee or cocoa the results were disappointing.

Use of the whole beans.—The whole beans may be used like other beans, boiled or baked alone, or in combination with pork, potatoes or rice. The characteristic strong flavor of soybeans can be removed easily and completely by soaking over night in a large excess of water. Hot water should be put into a large vessel and the beans should be suspended in a bag or colander just below the surface of the water to allow free diffusion of the substances out of the beans. The water should be changed in the morning and fresh hot water put on for an hour or two, after which the beans will be free from the original strong taste. The beans will cook up soft if a little soda is added to the water, but without the soda they remain rather tough and rubbery.

Soybean flour has a wide range of usefulness. In the opinion of a number of persons who have tried it, corn mush for frying is greatly improved by the addition of one-fourth soybean meal. The food value of the mush is greatly increased, and it browns in a much shorter time.

In several countries of Europe, soybean breads, containing about 25 percent soybean meal, are found regularly in the markets. Either meal with the oil left in it or meal from which the oil has been extracted may be used. The latter probably would keep longer, as the large amount of oil in the whole meal is likely to become rancid on long standing.

When the beans are from three-fourths to full grown, they compare favorably with green limas or with string beans. The pods are tough and undesirable to eat, but since the green beans are

difficult to shell while raw, they should be cooked in the pods. After cooking they shell very easily and are excellent served with butter or milk. It is well to boil them in salt water.

When properly roasted and prepared, the ripe soybean makes a good substitute for coffee, equal to many of the cereal preparations on the market.

The importance of the soybean as a food lies in the fact that it furnishes an extremely nutritious material at very low cost. Chart I shows the amount of digestible protein contained in a number of common foodstuffs, and Chart II shows the amount of food materials which can be purchased for $1 at normal prices.

These charts were prepared from data given by Atwater in Farmers' Bulletin 142 of the U. S. Department of Agriculture. In the computations the same percentage of digestibility was used for the protein of soybeans as for other beans, namely, 78. However, according to Kellner's tables[1] 92 percent of the crude protein of the soybean meal is digestible. The same authority gives the digestibility of soybean fat as 70 to 88 percent of the total amount present. On this basis the food value of soybeans is even greater than that indicated in the chart.

If only the percentage of protein is considered and cost is disregarded, Chart I shows that soybeans are much richer than any of the other foods listed here. They contain one-fourth more protein than the nearest rival, which is canned salmon.

When in Chart II we take into account the amounts of these foods which can be purchased for $1, soybeans again stand out with skimmilk as the only close rival. If we consider the high prices for foods that prevail at present, the economic importance of soybeans as a food becomes still more apparent. The calculations in Chart II are based on soybeans at the arbitrary price of 3 cents a pound, or $1.80 a bushel. This is lower than the present price of beans for seed purposes, but higher than the price paid to the farmers by the oil mills of North Carolina.

If soybeans were to come into general use as a food, two important results would follow, namely: The needed market for soybeans would become established and the growing of them would become more general, which seems to be desirable from the standpoint of the farmer; and, moreover, a large amount of highly nutritious food would be available at very low cost, thus affording relief from the constantly increasing cost of living.

[1] U. S. Dept Com, Bur For and Dom Com, Special Agents Series No. 84, Pt. I, p. 35.

CHART I

POUNDS OF DIGESTIBLE PROTEIN IN 100 POUNDS OF THE FOLLOWING FOOD MATERIALS

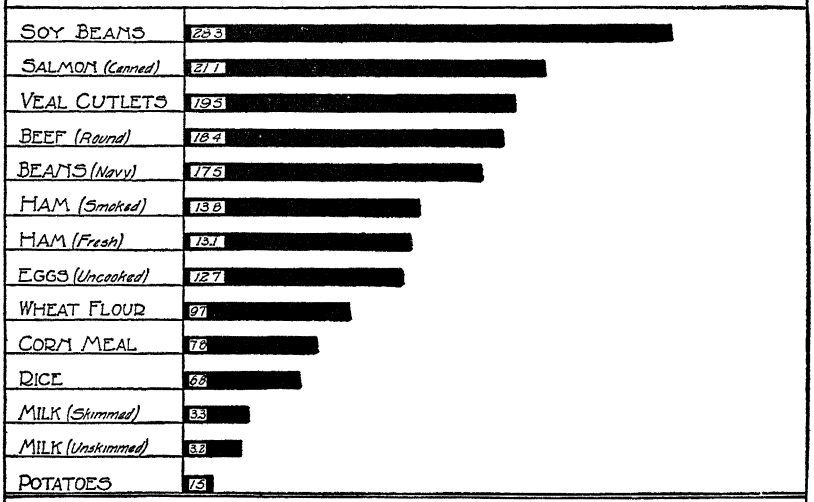


CHART II

ONE DOLLAR WILL BUY

	Lbs. raw material	Pounds of digestible protein	Pounds of digestible carbohydrate*
SOY BEANS 3¢ per lb	33.3	9.43	18.30
SALMON (canned) 15¢ per lb	6.6	1.40	1.70
VEAL CUTLETS 20¢ per lb	5.0	.97	.79
BEEF (Round) 15¢ per lb	6.6	1.20	1.80
BEANS (Navy) 5¢ per lb	20.0	3.50	12.30
HAM (Smoked) 15¢ per lb	6.6	.92	4.60
HAM (Fresh) 14¢ per lb	7.1	.93	3.90
EGGS (Uncooked) 36¢ per doz	4.1	.53	.81
WHEAT FLOUR 3¢ per lb	33.3	3.23	25.20
CORN MEAL 2½¢ per lb	40.0	3.12	31.10
RICE 8¢ per lb	12.5	.82	9.70
MILK (Skimmed) ¾¢ per lb	25.0.0	8.25	14.40
MILK (Unskimmed) 4¢ per lb	25.0	.80	3.40
POTATOES 1¢ per lb	100.0	1.30	14.20

*Starch, sugars and fats are stated in terms of starch for purposes of comparison